1 Introduction and Document Definition

This Conceptual Design Report proposes, discusses the suitability of, and reports our progress toward establishing a Deep Underground Science and Engineering Laboratory at the Homestake Mine in South Dakota. The scope for this Conceptual Design Report is established by the National Science Foundation Solicitation 06-614 [1] and more generally by the NSF's Major Research Equipment and Facility Construction Account Guidelines (NSF-03-049) [2]. These documents are included as Appendices A1 and A2 of this report.

This Conceptual Design Report responds to all the elements listed in those guidelines at an appropriate level of rigor.

1.1 Collaboration Goals for Homestake DUSEL

We propose to develop a dedicated, multidisciplinary laboratory for underground science. The Homestake facility will provide significant laboratory and research space at levels of 8000, 7400, 4850, 2000, and 300 feet (2438, 2256, 1478, 610, and 91 m) below ground, as well as providing extensive support facilities on the surface. Integrated into the science program and research facility will be a world-class education and public outreach program.

The proposed facility will support the DUSEL Initial Suite of Experiments. Those experiments run the gamut from physics (measuring or searching for dark matter, neutrinoless double beta decay, solar neutrinos, and geoneutrinos, as well as establishing facilities for nuclear astrophysics measurements); earth sciences (geology, rock mechanics, hydrology, coupled processes, seismology and extensive sensor arrays, geomicrobiology, ecology and environmental studies, and bioprospecting), and engineering (geotechnical studies, large cavities, and research into underground excavations). The Homestake facility will foster future investigations and research efforts by providing extensive capabilities to a wide range of fields.

The design of the Homestake facility is adaptable and readily expandable. Additional laboratory modules can be added to the facility with a minimum of impact on existing efforts.

We present our current plans for underground laboratory and common space at these levels in Table 1.3. Additionally, surface support buildings include a 50,000 square foot (4600 m^2) education science center and 100,000 square feet (9300 m^2) of support buildings, assembly buildings and shops. The support buildings will be, in some cases, adapted from existing structures.

Table 1.1 Underground laboratory space for the DUSEL Initial Suite of Experiments and future expansions. Estimates do not include the access drifts or underground connecting tunnels, nor do they include the many other drifts or former mining areas that could be made available for nomadic research purposes. The term "mwe" means "meters of water equivalent" and describes the cosmic-ray attenuation value of the Homestake rock formations [3].

Level below ground	Laboratory Floor Space (m^2)	Laboratory Volume (m^3)	Common Space (m^2)	Common Space Volume (m^3)
300ft (91m, ~233 mwe)	640	6800	150	1,500

Level below ground	Laboratory Floor Space (m^2)	Laboratory Volume (m^3)	Common Space (m^2)	Common Space Volume (m^3)
4850ft (1478m, ~4100 mwe)	7200	65,000	2800	40,000
7400ft (2256m, ~6400 mwe)	4500	40,500	1500	15,000
8000ft (2438m, ~7000 mwe)	100	1000	-	-

In this report we also discuss management structures that will oversee maintenance and operations of the facility and its multidisciplinary scientific program. Of the highest importance will be a fully integrated environmental, health, and safety program. This program will involve many of the elements developed during Homestake Mine's 126 year record of safe operation. However, the safety program must involve many new elements required by the scientific program. It will stress the safe integration of many new users, including students, visitors, and scientists, as well as the personnel traditionally associated with underground excavation.

1.2 Homestake's Approach

Our approach to creating DUSEL is to acquire and adapt the existing and closed Homestake Gold Mine in Lead, South Dakota. Our approach defines a dedicated laboratory that has no interfering or competing uses for its infrastructure.

To host our proposed DUSEL Initial Suite of Experiments, we have defined initial research campuses at levels 300, 4850, 7400, and 8000 feet below ground. We target several long transverse drifts (tunnels) for specific earth-science applications, including seismic arrays (on levels 2000 and 3900 below ground, as well as the extensive ramp system). The principal levels in the Homestake facility that are of interest to research are described in Chapter 7, Section 7.5.

For the DUSEL Initial Suite of Experiments, we will rehabilitate and modernize the conveyances that provide access from the surface to 8150 feet underground. Upgrades and improvements to the conveyances, drifts (tunnels), ventilation, and communications are included. We will make use of existing excavations, as well as providing new customized laboratory and research space. Surface support buildings will also be customized to provide necessary services for users.

We propose a phased approach to the development of the laboratory. Initially we will focus on the surface and 4850 Level campuses. Then we will focus on the development of additional laboratory modules at the 300, 7400 and 8000 Levels and further enhancements to the higher-level campuses. In total, Homestake DUSEL has the potential to expeditiously access over 30 km^3 of rock with existing drifts, ramps, and shafts.

To design and propose the Homestake laboratory, we have assembled an experienced and diverse scientific collaboration, the Homestake Scientific Collaboration, and coupled this to a state entity, the State of South Dakota Science and Technology Authority (the Authority). The Authority was established in 2004 to provide means to take title of the Homestake Property and to promote its use for science and engineering research [4] (see Appendix A3). The Homestake Scientific Collaboration is primarily tasked with defining the scientific, engineering and educational goals along with the scientific roadmaps and the laboratory requirements. The Authority is responsible for the acquisition of the facility, including the necessary antecedents of

liability and indemnification statues, insurance, title, and the rehabilitation of the infrastructure. The DUSEL project team is comprised of members of these two bodies.

Through the combined efforts of the Homestake Scientific Collaboration and the Authority, the Homestake site will host scientific, engineering and educational efforts in advance of the NSF-supported DUSEL. We refer to this Authority-supported laboratory as the "Homestake Interim Laboratory." This early phase provides essential underground laboratory space and environments for the research and development of many components of the proposed DUSEL Initial Suite of Experiments. More-advanced experiments in the next phase, the NSF-supported DUSEL, will benefit from the much-needed underground space.

1.3 Homestake Key Characteristics

We list here some of Homestake's key characteristics. These and others are presented in greater detail in subsequent chapters, particularly Chapter 5.

The Homestake site encompasses over 30 km^3 of rock with depths accessible to 8150 feet below ground using existing shafts, drifts, and ramps. The site is capable of hosting a comprehensive suite of experiments. The full complement of S-1 identified fields of science and aligned research would be hosted at Homestake DUSEL. (The S-1 Report, Deep Science [5], is included in Appendix A4.) The DUSEL Initial Suite of Experiments would include all of the proposed experiments requiring extremely low backgrounds and very large detectors in particle and nuclear physics. Homestake DUSEL would also host a rich, diverse multidisciplinary variety of deep subsurface studies in geosciences, geoengineering, and microbiology. As noted in the S-1 report, certain earth-science experiments requiring sedimentary or granitic rock would be conducted in those rock types at separate sites, as no single site can readily provide all basic rock types. Science uses and access to the facility will be unimpeded by other activities.

Homestake DUSEL will be situated in competent, well-characterized rock. Existing large-scale excavations, including large caverns at the 4850 and 7400 Levels, demonstrate long-term stability of excavations at significant depths. Several independent geotechnical studies support the suitability of the Homestake formations for the creation of underground laboratories and research space. The site will accommodate an evolving science program of great longevity—at least 30 years.

The diverse and scientifically interesting geology provides for a rich geosciences program. There exists over a century of operations and safety records, maintenance logs, and geologic information, already being organized and made available for scientific purposes.

Homestake DUSEL benefits from extremely strong state and local backing, including financial, technical and logistical support. With the Authority funding and the Sanford donation, the Authority controls $116M allocated for the creation of Homestake DUSEL. Title to the entire facility is now held by the Authority. Issues regarding indemnification and insurance have been defined and resolved.

We are following a professionally prepared and externally reviewed plan for re-opening the mine, focusing on underground safety, rehabilitation, dewatering, and providing safe access to levels greater than 8000 feet below ground. Regaining underground access and dewatering the entire facility is anticipated to cost ~$50M and require ~18 months. We plan on beginning the rehabilitation in Spring 2007. On 10 June 2006 a camera system was lowered down the Yates shaft and recorded the good condition of the entire shaft and infrastructure. On 7 December

2006, cameras were sent down the Ross shaft and similarly recorded its good condition.

The Authority is initiating this plan to preserve and rehabilitate the Homestake mine and consequently create the Homestake Interim Laboratory. The Authority's plan includes providing five years of operating support and access for science, from the surface to the 4850 Level. The Authority has expanded its staff to prepare for the reentry plan and to oversee detailed engineering. There exists an available experienced, trained and knowledgeable workforce in the area. The management entity, including critical Environment, Health and Safety (EH&S) components, is being developed for the Homestake Interim Laboratory, and includes many individuals with years of experience in the Homestake mine.

To guide science planning for DUSEL and in particular for the Homestake Interim Laboratory, a diverse, international user pool was established with a call for Letters of Interest. As a result, ~85 responses were received. These Letters of Interest [6] (see Appendix A5) have been peer reviewed by an external Homestake Program Advisory Committee composed of independent experts in physics, geoscience, engineering and biology. Their advice and the S-1 working group's reports strongly influenced our preliminary plans and designs for the Homestake Interim Laboratory and help us in establishing a roadmap for developing DUSEL at the Homestake site.

Establishing the Homestake Interim Laboratory provides reduced project risks, accurate schedules, and lower DUSEL capital costs. Additional attractive Homestake DUSEL features include: a) expeditious, safe, deep underground access and research space provided by existing shafts and drifts with no competing uses; b) an agency and organizational structure to make the best use of this dedicated access; c) existing surface facilities at the site to support and foster the scientific and outreach programs; and d) identified and accessible rock and water disposal sites adjacent to the facility.

Homestake DUSEL further benefits from well-established characterization of a) the rock mass established from the existing drill core repository and mining/geologic database; b) the water inflows and sources; and c) the levels of intrinsic radioactivity in the rock mass and levels of radon in the entire facility. The levels of uranium, thorium and potassium in the Yates metamorphic formation, based on several existing core samples, are an order of magnitude lower than in typical granitic formations such as the Canadian Shield, Cascade Range, etc.

An integral part of the Homestake Interim Laboratory's program is effective use of existing efforts to foster education and public outreach programs at the historic site. These efforts are connected to existing NSF-funded South Dakota programs and will continue to be developed as an integral part of DUSEL.